the innumerable minute *Scolyti*, for instance, and only radical measures, from the very beginning of the supervision of our forests by the officers of the Department, may partially eradicate the evil. We have the results of the same measures carried out in other countries, and I will not dwell on their efficacy, more or less ascertained.

The object of this paper, which I do not in any wise deem scientific, is simply to call your attention to the number and varieties of insects injurious to Forest trees, and also to ask for some information on the life-habit of those insects.

As I have said before, nothing is known on that subject, and what is needed is: true and reliable observations in different parts of the country. One man alone cannot do much. I cannot, for the present, at least, visit those districts where forests are found, but I would gladly make out, to the best of my abilities, those species which would be sent to me for that purpose, and keep due record of the observations which my correspondents would favour me with.

And then, I hope, that by manifold researches of that kind, we will be able, in time, to know the name and be acquainted with the life-history of those insects that are prejudicial to a certain given tree, as is now the case in European Countries and in the United States of America.

EXHIBITS.

Three drawers of Beetles.
One box of Bombycidae.
One box containing *Ledo Venus* and *Cossus*.
One piece of Ebony Wood.
Two showing the galleries of *Ledo Venus*.
One box containing *Alaus moerens*.
Larva of *l'Alaus moerens*.

AN INVESTIGATION INTO THE ISOBARIC INFLUENCES AND CYCLONIC PATHS OF SOUTH AFRICA.

By Adolph G. Howard.—April, 1885.

To the President and Members of the South African Philosophical Society.

Gentlemen,—In placing before you the following investigations into the Meteorology of South Africa, with my theories based thereon, I do not wish to convey the idea that they are facts fully proved, because such most decidedly is not the case. I wish them to be understood as representing merely the chrysalis from which a fully developed and practical law may ultimately be established, so that I merely offer them as a basis on which others (or perhaps myself) may erect a more useful superstructure.

The reason which induced me to make meteorology a study in this Colony, was the assertion of a friend of mine, soon after I arrived here, to the effect that the barometer always rose with a south-east

and fell with a north-west wind. This would of course be the case if the atmospheric waves travelled from S.W. to N.E., and as the great European waves travel from N.W. to S.E., I naturally supposed that the reverse would be the case here, and moreover my friend's assertion went to prove it.

But upon actually observing these phenomena myself, I was very much surprised to find the reverse the case.

Continuing my observations, I further discovered that the barometer very often fell, rose, and then fell again, the wind blowing from some point of south all the time, after which a north wind would set in, and the barometer begin slowly to rise. By this it was evident that the waves passed over us from north to south, and that cyclonic disturbances were passing us from north to east.

Again, and especially during the winter months, the barometer would fall with a northerly wind, which, chopping to the west, generally brought rain and a rising barometer, the wind ultimately going round to the S.W. These were evidently cyclones passing by the south of the Cape to the eastward.

It was not until the beginning of last year that I began a serious investigation of the storms of South Africa, at which time a daily report began to be issued by the Meteorological Commission from ten stations, principally on the coast, and from these I essayed the formation of synoptic charts, with a success beyond my expectations.

This year, through the kindness of Mr. Fry, the Secretary to the Meteorological Commission, I have obtained access to the up-country registers for January, and having reduced them to an approximate sea level, have plotted for each day on the series of charts marked A (and which I have lent to illustrate the paper) the differences whether for rise or fall between the reading on that day and that of the day before. Each station I have indicated by a small open circle, and where the barometer was either rising or falling I have shown this by a small red or black dot, the red meaning a rise and the black a fall. When the extreme limit on either side has been reached, the circle is entirely filled in with the indicating colour. Besides this I have plotted on the direction and force of the winds. By glancing at this series of charts it can be seen in a moment where the barometer is lowest and where highest, where rising and where falling. Moreover by following the directions of the wind it is possible to define where the areas of low or high pressure are situated.

The series of charts marked B (also lent to illustrate this paper) shew the utility of synoptic charts, and the fact that it is possible to prepare them if we can secure proper stations properly equipped. I am of opinion that it will be through the medium of synoptic charts, and by them alone, that the true data of South African storms will be arrived at, and the sooner some good stations are founded the better for our meteorology.

With these preliminary remarks I will proceed with my paper.

Before devoting my time to the study of South African meteorology, I made myself thoroughly acquainted with that of the Northern Hemisphere, because there are many things which are applicable to all places, such as the formation of cyclones in the permanent areas of low pressure ; and that part of the world (that is, from Europe to America,) is so favourably situated for investigation, and has had such an amount of study devoted to it by the very best men of the day.

I shall refer as little as possible to the Northern Hemisphere, so will now state that I have taken the conditions there as a basis, and have proceeded on the assumption that "like conditions give like results," reversed, of course, on account of the different hemisphere.

* * * * * *

To Professor Buys Ballot of Utrecht belongs the honour of placing on record the law of the relationship between winds and gradients.

For the Southern Hemisphere the law is, "Stand with your back to the wind and the barometer will be lower on your *right* hand than on your left." Thus when a south-east wind is blowing in Cape Town the area of low pressure must be to the north-east, and the steeper the gradient the stronger will the wind blow.

The wind, as a rule, neither blows direct to the area of low pressure nor parallel to the isobars, but takes an intermediate course, blowing nearly parallel when far removed from the centre of low pressure, and nearly at right angles to them when close in: this centre is generally an area of dead calm. Hence it is evident that we have to examine the configuration of the isobars to arrive at the direction of the wind.

Isobars, though they are constantly changing, and form themselves into almost every shape, have several recognizable and general forms, the two principal ones being the cyclone and the anticyclone, the relative positions and pressures of which govern the weather of the world.

A cyclone is an area with the lowest barometer reading at the centre and the highest round the edges, the wind of course circling inwards, according to Buys Ballot's law. A cyclone can be of any size, and although the circular form is generally noticeable, still they are often so distorted as to appear of almost any shape.

To shew the immense size of some of these I may mention that it is no uncommon thing for one of them to rest over the whole North Atlantic, so that New York, Newfoundland, Greenland and Europe are being influenced by the same atmospheric circulation. On the 12th of November, 1875, one of these depressions covered the whole of Europe with the exception of Spain.

Although cyclones are often of such grotesque forms, still they have many points in common, and, as I said before, the circular form is generally noticeable, especially as the central isobars are reached, so that they are easy to be seen on a synoptic chart.

Besides this, there is a great similarity of weather in them, so that by examining one system we have the approximate conditions for them all.

Let us, therefore, imagine a cyclone to be situated over South Africa, and travelling from north to south. Having plotted it down on a chart, and divided it into four quadrants by lines running from north to south, and from east to west through the centre, the following is the weather we should expect to see.

South-west Quadrant.—To the south and west thin cirro-stratus, with a pale moon and perhaps a large halo. As the trough is approached the sky becomes overcast and threatening with heavy cumulo-stratus. Further from the centre, cirrus blown from the S.E. will be seen. Just as the trough is reached, if near the centre, a few misty showers will fall, but if away from the centre the cirrus will be clearing away to the south, and a hard blue sky be seen.

North-west Quadrant.—Mostly a blue sky, with the exception of occasional patches of detached cumulo-stratus.

South-east Quadrant.—To the south the usual watery sky with a halo round the moon, while further to the north very gloomy and threatening weather will be experienced. As the trough is approached we will find near the centre drizzle and driving rain, and further to the east a gloomy sky with dense cumulo-stratus.

North-east Quadrant.—Showers and squalls, followed by detached cumulus, windy cirrus, and finally blue sky.

The foregoing is the general description and position of the weather in a cyclone, but of course several conditions have a varying tendency, and considerably modify the weather: thus the presence of an anti-cyclone will increase the gradients, and cause more intense weather on that side than on the others.

Another cause of variation is when a secondary forms, which generally takes place along the prolongation of the trough or against an area of high pressure. The effect of this is to increase the force of the wind on the side furthest from the primary, and to reduce it between them, sometimes causing a dead calm.

The secondary forms a most important factor in the study of South African Meteorology, as scarcely a cyclone passes without having a secondary developed over the south-western districts.

Sometimes when a cyclone is in close proximity to two areas of high pressure a V depression is produced, which also modifies the weather.

An anti-cyclone is in every way the converse of a cyclone, the isobars, in this case, enclosing an area of high pressure, the circulation of wind being the reverse of that in a cyclone. Anti-cyclones are of all conceivable shapes, but are generally longer from east to west than from north to south, very often rising into two or more heads. When an offshoot takes the form of the letter V, it is called a wedge, and plays an important part in the formation of secondaries.

When two anti-cyclones approach close to one another they are generally joined by a neck of comparatively low pressure called a "Col," a formation of a very treacherous nature, because upon the near approach of a cyclone the tendency is for secondaries to form in this "Col," and it then becomes a matter of great doubt which way the secondary will travel.

The only other barometric influence affecting the weather is caused by waves travelling from the low pressure areas towards those of high pressure. In the central areas of low pressure the barometer is seldom stationary, but keeps on gently rising and falling. This oscillation causes a series of ring waves to flow outwards, similar to the wavelets caused by dropping a stone into still water.

With the foregoing general types of isobaric forms we will now devote a short time to the consideration of the storms, &c., of South Africa.

On Chart C, Nos. 5 and 6, I have delineated the mean barometer readings for the months of January and July, over that portion of Africa and the adjacent seas which affect Cape Colony.

We will first devote our attention to January's chart, and see how the differences of level influence our weather.

On either side of South Africa is to be seen an area of high pressure. These are called respectively the South Atlantic and Indian Ocean permanent anti-cyclones, and are joined together by a "Col."

To the north is the assumed low pressure area of Central Africa. The limits or position of this area are, of course, not known, but all the surrounding conditions go to prove that such a depression does exist, because in no other way can our summer storms be accounted for.

To the south of the two anti-cyclones is the south sea belt of low pressure which completely surrounds the South Pole.

It is from the area of low pressure to the north of us that the great majority of our summer cyclones come, the motive power of generation being the great South Atlantic anti-cyclone.

Neither cyclones nor anti-cyclones are ever motionless, but are constantly varying in shape and pressure, the accompanying chart merely giving the mean of a very great number of years. The reason of this is that the two areas, high and low, are constantly reacting on one another. The air in the depression is more rarified at one time than at another, and consequently the quantity of atmosphere flowing onto the neighbouring high pressure areas varies, hence these areas fluctuate both in pressure and size, sometimes almost embracing the low pressure areas. When such a state of relationship exists, there is a great inclination on the part of the low pressure area to form a secondary, which is accelerated if the high pressure forms itself into a wedge.

Anti-cyclones change very slowly, and cyclones very quickly, so it can be seen how several of these secondaries may form, become veritable cyclones, and pass to the south before the anti-cyclone changes its shape.

On the same chart, Nos. 1 to 4, I have depicted the formation of an imaginary cyclone, the area of high pressure extending along the coast and almost embracing the depression on the north. On No. 1 we have a cyclone passing off the Colony, while a secondary is forming to the S.W. of the central depression. In No. 2 the whole system has moved further to the S.W., the secondary has increased in proportions, and the permanent area decreased. Low pressure exists at Natal, where the last depression is passing to the eastwards. On No. 3 the secondary has become a veritable cyclone, and is travelling to the south, while the permanent area has retreated and assumed its original proportions. Lastly, on No. 4 the cyclone is fairly over the Colony, and has developed a secondary towards the S.W. Another secondary is forming in the permanent low pressure area, and as long as the relative position of anti-cyclone and depression remains unaltered the same sequence of weather will be experienced. The colonial isobars of these diagrams were taken from my synoptic charts for the 17th to 20th January of this year. Of course when the shape and pressure of the anti-cyclone changes, the paths of the cyclones will change also.

The foregoing diagrams merely illustrated the formation of a cyclone on the S.W. side of the central depression, but I am of opinion that they are formed all round this area, those on the eastern side, if they do notmove away eastwards at once, will revolve round from E. by S. to W., and then if not retarded by an anti-cyclonic wedge, will pass off and be lost in the S.E. trade zone of the Atlantic; but if the anti-cyclone bars their further progress, they will be deflected and travel south, and pass off to the east.

These I call the summer cyclones, in opposition to the winter ones to which I shall refer later on.

By referring to the weather in the typical cyclone mentioned before, we can form a very fair estimate of that which may be expected to visit the different districts traversed by the cyclone. In the western districts, as it approaches, thin cirro-strati will be seen, with a halo round the moon, as the trough is approaching cumulo-strati will be developed, and high cirri blown into threads from the south-east. The wind will meanwhile back, or veer as the case may be, to the east and south-east, going more to the south as the trough approaches. As soon as the barometer begins to rise a few hazy showers may fall, or else a dense fog form, when the wind freshening from the south, will ultimately blow strong with a rising barometer and a hard, clear sky. I think it must be confessed that the foregoing is a very accurate description of the sequence of weather in Cape Town during the passage of one of these cyclones.

The heaviest rain would naturally fall over the north-eastern districts. Thunderstorms are prevalent in the advancing left hand quadrant, consequently the north-eastern districts with Natal would be very subject to them during the summer months. Moreover, as this is the wettest half of the cyclone, these same districts would have their wet seasons during summer and autumn, and comparatively dry seasons during the other two quarters.

Now what are the real facts of the case? According to Mr. Gamble's rainfall means, the N.E. and Eastern Districts of the Colony, with very few exceptions, have their wettest months during the summer, while the west and S.W. districts have their driest months then. I think this of itself proves the general track of summer cyclones.

When a cyclone advances over the Colony from the N. or N.W. it is usually checked in its onward career by the comparatively higher pressure to the south of us, but as this higher pressure is merely the "Col" joining the two anti-cyclones, there is a great tendency for the cyclone to develope a secondary in it, and we know from experience that primaries and secondaries, and often two or more cyclones, very often coalesce to form one again; the whole system very often in this way passes through the "Col," and is lost in the south seas. A case of this kind was experienced over Europe in June, 1882. On the 26th a "Col" lay to the east of England, joining two anti-cyclones, one north and the other south. A small secondary was near Aberdeen, while the primary was advancing on the coast of Ireland. The forecasts were issued on the assumption that the cyclones would advance to the north and the "Col" remain intact, but by next morning the two cyclones had coalesced and formed a single system, which was passing *between* the two high pressure areas, over the exact spot where the "Col" was the day before. I have heard doubts expressed as to the possibility of a cyclone breaking through a bank of higher pressure, but from experience this is often known to be the case in Europe, and I see no reason to doubt the possibility of it here. But very often the advancing cyclone *is* checked by this bank, and either fills up and dies away, or else passes off to the east. The result of this is what one would look upon as a contradiction. According to the law of winds as the cyclone advances we would expect N.E. winds in Natal, east winds round the coast, and S.E. winds at the Cape, all changing to S. as the cyclone moved away to the eastward. But if the "Col" happens to stretch across the Colony, so as to have gradients for west winds at, say Cape St. Francis to Port Alfred,

these places will not be affected by the cyclone, and the in nowise uncommon occurrence of N.E. winds at Natal and East London, S.E. at the Cape, S.W. at Cape L'Agulhas, and W. or N.W. winds at the other coast ports, will be experienced.

Another source of variation is the almost invariable formation of a secondary against the Atlantic anti-cyclone, which secondary always passes close to Cape Town and intensifies the S. or S.E. wind there and at Cape Point by increasing the gradient. Sometimes a secondary forms on the "Col," which, becoming an independent cyclone, passes off to the S.E., while the primary travels to the N.E.

All these conditions make the forecasting of weather round the coast very difficult.

I am of opinion that sometimes this "Col" is absent for several days at a time, and if during that period a cyclone approaches it is sure to pass to the S. or S.E. The centre of a cyclone travelling from N. to S. passed over Cape Town on the night of the 2nd of this month (April), the wind chopping very suddenly from S.E. strong to N.W. fresh. By the foregoing it will be seen how beneficial it would be to know the true state of the atmosphere in this region upon the approach of a cyclone.

I cannot pass over this portion of my paper without referring to the immense value that would be attached to stations further north, say at Port Nolloth and Walvisch Bay. Of course at the present time telegraphic communication with these stations has not been established, consequently it would be useless to refer to them in any other way than to shew their importance for the future, when perchance they may be joined to Cape Town by wire. Whenever a depression is advancing from the north, Walvisch Bay will be the first to feel it. An east wind with a falling barometer will be the sign of its approach. If the wind becomes more northerly the depression will pass off to the Atlantic, but if it turns to the S.E and S., the cyclone is travelling southwards, and will pass over the Colony. The next stations to watch then are Bloemfontein or Kimberley and Port Nolloth, between which most of the cyclones pass. By carefully noting the changes of wind at these places the path of the storm can easily be followed.

I do not think I need say anything more in connection with these summer storms; I hope I have placed enough before you to influence a further investigation, which I sincerely trust to see before long worked out into a practical form, and if through the instrumentality of these few ideas anybody succeeds in advancing practical meteorology in South Africa I shall be satisfied.

I shall now pass on to what I call the winter cyclones. By referring to the charts for both January and July, it will be seen that a permanent area of low pressure exists to the south of us, but that whereas the positions of the anti-cyclones during January cause the storms formed in this area to have but little effect on the Colony, their positions during July being much further north, exposes the whole Colony to the full force of the South Sea cyclones. Furthermore it will be noticed, on July's chart, that the area of low pressure to the north has entirely disappeared, or travelled so far north that its effects cannot be felt over South Africa, thus it is that though a few of these winter storms make their influence felt during the summer months, during winter they are the *only* type that ever visit us.

These storms must be generated on the southern edge of the Atlantic anti-cyclone, somewhere to the west of us, and travel from west to east. By referring to our typical cyclone we will be enabled to judge the sort of weather which might be expected.

The position and size of the Atlantic anti-cyclone will also affect the path of these storms and cause them either to advance to us from a W.N.W. or a S.W. direction, from either of which points, or somewhere between them they always come. The position and size of the Indian Ocean anti-cyclone will also govern the direction they leave us. Numbers of these depressions come from the S.W., pass the Cape from west to east, and leave us in a south-easterly direction, their path being in the form of the arc of a circle. Others again come from a W.N.W. direction, and pass by us towards the S.E.

There is very little doubt that secondaries are of as common an occurrence on the northern edges of these cyclones as they are on the S.W. edges of the summer ones; in fact I am of opinion that the great majority of our winter weather is caused by these secondaries, for in no other way can we account for the directions of the wind. Captain Toinbee has proved that these South Sea depressions are of enormous magnitudes, stretching from the South Coast of Africa to the 70th parallel of south latitude, so that if our weather were merely affected by these larger depressions, our winds would only range from N.W., through W. to S.W., but very often the approach is heralded by N.E. winds all round the coast, and the constant phenomenon of the wind suddenly chopping from N. to W. as the trough passes, points to the fact that the centre is not very far from us, and consequently these depressions must be of small dimensions as compared with the great South Sea cyclones, and must either be secondaries or small independent storms generated, as I before said, on the southern edge of the great South Atlantic anti-cyclone.

But the question as to whether these storms be secondaries or not does not affect our meteorology very much, because they are of such dimensions as to bear all the characteristics of independent cyclones, in which light we can study them. Smaller secondaries are often formed against the South Atlantic high pressure area, which secondaries materially affect the Cape Peninsula, causing the wind to blow from the N.W. when a S.W. wind would have been prognosticated.

An example of this may be seen in the storm which passed us from the 21st to 24th of March this year. On the 21st the barometer was steadily falling with a N.W. wind and all the atmospheric indications of a winter storm. The predictions for Cape Town would have been a sequence of N.W., W., and S.W. winds. On the 22nd the wind went more to the W.N.W., the indications increased, and a thunderstorm broke over Piquetberg, with a few showers here. On the 23rd the barometer had risen, but instead of the wind being S.W. it was N., ultimately turning to N.W. and W. Heavy showers fell all day. On the 24th the wind remained at W. till the afternoon, when it backed to the N.W. again. Slight showers fell all day. Next day the wind was S.W., and the barometer reached its maximum. By studying the foregoing it is very evident that a secondary formed to the west of us, which altered the direction of the wind here on the 23rd and 24th.

These secondaries upset much of our forecasting if they are the

exception, but when they are the rule, which I believe is the case with these storms, we know then what allowances to make. For instance, when a winter storm is approaching, look out for strong N.W. and W. winds with heavy rain at Cape Town, when the barometer begins to rise.

The last type of storm I wish, for the present at least, to bring to your notice, is akin to the winter type. The conditions are these: A strong N.N.E. wind is accompanied by a falling barometer and all the indications of the left-hand advance quadrant of a cyclone. As soon as the rain falls, which it generally does in heavy squalls, the wind veers to N. and N.W., when the barometer begins to rise. This I take to be caused by a high pressure wedge over the Colony, deflecting the cyclone and causing it to travel from north to south, and very likely the same storm might be recognised a few days later in the Eastern Districts travelling from the S. or S.W.

The storm which passed us from the 8th to the 11th of last February, was deflected in this way by a wedge of high pressure over the Colony. During the passage of this storm (which was an exceptional one for summer), the barometer fell considerably at the coast stations, amounting to four-tenths at Port Elizabeth and three-tenths at Cape Town, while at Kimberley and Bloemfontein it remained approximately steady.

As a passing remark I will mention how fortunate it is for the Colony that the permanent anti-cyclones are not always of one form, for if such were the case, no western storm would ever reach us during the summer months, and as a consequence the western and southern districts would be no more than a drought-stricken wilderness for four or five months each year.

I cannot conclude without recording my sincerest thanks to Mr. Fry, the Secretary to the Meteorological Commission, for the kind and courteous manner in which he has placed the various data at my disposal, and also to Mr. Gamble, who so kindly consented to read this communication.

I hope that before long I, or someone else better able to do so, will have brought these theories of mine into a more tangible form, and that the actual practical deductions will be greatly in excess of theoretical ideas.

Meteorology is not a science reduceable by mathematical rules, nor do I believe it ever will be. Astronomy has to deal with solid and unyeilding bodies governed by fixed laws, but though, no doubt, there *is* a law governing the formation of atmospheric pressures, still the materials we have to deal with are of such a changeable nature, that even the contour of the earth's surface will cause a material deflection. Astronomy has taken many thousands of years to bring it to its present degree of precision, and even now it is not perfect, and although we have greater advantages now, than had those who in former years traced the science of Astronomy through such grotesque and tortuous windings and absurd theories and investigations, still it will be many, many years before Meteorology can be looked upon as, it will ultimately be, the younger brother to Astronomy.

In conclusion, Mr. President and Gentlemen, let me thank you for having listened so patiently to the foregoing, and my only hope is, that some of these ideas will be food for thought, for if I have but caused one more to care for the study of Meteorology, and to advance on a train of ideas which he would never have thought of doing but for this paper (whether for or against my theories), I am satisfied.